

Nasalance Changes Following Various Endonasal Surgeries

Hazem Saeed Amer¹ Ahmed Shaker Elaassar¹ Ahmad Mohammad Anany¹ Amal Saeed Quriba²

¹Department of Otorhinolaryngology - Head and Neck Surgery, School of Medicine, Zagazig University, Zagazig, Egypt

²Department of Otorhinolaryngology - Phoniatic Unit, Zagazig University, School of Human Medicine, Ringgold Standard Institution, Zagazig, Egypt

Address for correspondence Hazem Saeed Amer, MD, Department of Otorhinolaryngology-Head and Neck Surgery, Faculty of Medicine, Zagazig University, Zagazig 0020552322665, Egypt (e-mail: hazemamerent@yahoo.com).

Int Arch Otorhinolaryngol 2017;21:110–114.

Abstract

Introduction There is change in nasalance post endonasal surgery which is not permanent.

Objectives The objective of this study is to evaluate the long-term nasalance changes following different types of endonasal surgeries.

Methods We included in this study patients who underwent sinonasal surgery at the Otorhinolaryngology Department in Zagazig University Hospitals from February 2015 until March 2016. We divided the patients into two groups according to the surgeries they underwent: Group (A) was the FESS group and group (B), the septoturbino-plasty group. We checked nasalance using a nasometer before and after the sinonasal surgery.

Results Nasalance increased at one month after the operation in both groups. However, it returned to nearly original levels within three months postoperatively.

Conclusion FESS, septoplasty, and turbinate surgery may lead to hypernasal speech. This hypernasal speech can be a result of change in the shape and diameter of the resonating vocal tract. Hypernasal speech in these circumstances may be a temporary finding that can decrease with time. Surgeons should inform their patients about the possibility of hypernasality after such types of surgery, especially if they are professional voice users.

Keywords

- ▶ speech
- ▶ turbinate
- ▶ endoscopy
- ▶ sinusitis

Introduction

The resonance of voice is determined by two factors: voice source and vocal tract. The supraglottic larynx, tongue, lips, palate, pharynx, nasal cavity, and possibly the sinuses, act as resonators. Any alterations in the configuration of these structures may produce substantial changes in voice resonance.¹

One of the most important factors of speech quality is nasal resonance. Vocal amplification in the oral and nasal cavities is responsible for resonance and is classified into hypernasality,

hyponasality, and mixed resonance. Hyponasal speech may be present in patients with nasal obstruction such as choanal atresia, nasal polyps, and septal deviation, since narrow nasal airways and hypernasal speech usually exist in patients with a cleft palate and velopharyngeal incompetence.²

The nasometer is a computer-based instrument that consists of a headset that has directional microphones for the nose and mouth. These microphones are separated by a baffle that rests against the upper lip. Use of the nasometer in the evaluation of resonance is done by picking up acoustic energy from the nasal and oral cavities, then computing the ratio of

received
August 6, 2016
accepted
November 6, 2016
published online
February 10, 2017

DOI <http://dx.doi.org/10.1055/s-0037-1598035>.
ISSN 1809-9777.

Copyright © 2017 by Thieme-Revinter Publicações Ltda, Rio de Janeiro, Brazil

License terms



nasal acoustic energy to total (nasal plus oral) acoustic energy, and displaying this in real time. In this way, an average “nasalance” score can be computed for a given speech segment. This instrument gives objective information regarding resonance and nasality.^{3,4} However, the examiner must interpret the scores based on knowledge regarding resonance and articulation.⁵

Chronic rhinosinusitis is an inflammatory disease of sinonasal mucosa. The swollen sinonasal mucosa and closed sinus ostia decrease the nasality. Recently, functional endoscopic sinus surgery (FESS) has been introduced as a successful management for chronic rhinosinusitis. Studies have reported that nasal volumes change after FESS.²

Although many previous studies⁶⁻⁸ have reported that patients who have undergone endoscopic sinus surgery for chronic rhinosinusitis complained from perceptual changes in voice sound, the relationship between nasality and functional endoscopic sinus surgery (FESS) has not received enough attention by researchers.

The current study aimed at evaluating nasalance changes after different types of endonasal surgeries including FESS, septoplasty, and turbinate surgery.

Patient and Methods

We conducted this study at the Otorhinolaryngology Department over the period from February 2015 until March 2016. The study received approval from the Institutional Review Board of our institution. All participating subjects gave informed consent. The study included 48 patients (Arabic speakers), which we divided into two groups: group (A) included patients who had chronic rhinosinusitis and underwent FESS through the Messerklinger technique; and group (B) included patients who had chronic nasal obstruction due to deviated nasal septum and hypertrophied inferior turbinate and underwent septoplasty with or without turbinate surgery.

We excluded from the study patients with extensive sinonasal polyposis, patients with history of cleft lip, cleft palate, or submucosal cleft palate. We also excluded patients with history of previous nasal surgery, tonsillectomy, or uvulopharyngopalatoplasty, or a combination of these.

The participants included were preoperatively subject to full history taking, full nasal examination, including anterior rhinoscopy, and endoscopic endonasal examination CT scan for nose and paranasal sinuses for all cases.

Participants also underwent postoperative endoscopic endonasal examination at one week, one month, and three months postoperatively to assess postoperative surgical results.

We conducted a speech assessment on all participants one to two days preoperatively then repeated it at one month and three months postoperatively.

Every patient went through the speech assessment protocol that is applied in the Phoniatic Unit of our department.^{9,10} It included:

(A) Video-nasoendoscopy:

We examined all the patients preoperatively using a flexible fiberoptic nasopharyngeal endoscope (Xion Medical, Berlin, Germany). We recorded and graded the velopharyngeal valve movement and closure from grade 0 to grade 4 as follows: (0 = the resting (breathing) position or no movement; 2 = half the distance to the corresponding wall; 4 = the maximum movement reaching and touching the opposite wall). Pattern of VPI closure was specified, whether circular, coronal, sagittal, or others. While the patient was repeating the speech samples following a recommendation given by an International Working Group,¹¹ we also documented the pattern of velopharyngeal valve closure as circular, coronal, or sagittal. This velopharyngeal endoscopy was done to exclude the presence of associated velopharyngeal incompetence. We excluded from the study any patient that had even a mild degree of velopharyngeal incompetence.

(B) Auditory Perceptual Assessment (APA) of speech:

The subjective evaluation of patients' speech in a free conversation included type (hyponasality or hypernasality) and degree of nasality, consonant precision, the compensatory articulatory mechanisms (glottal and pharyngeal articulation), facial grimace, audible nasal emission of air, and the overall intelligibility of speech. All these elements are graded along a four-point scale in which 0 = normal and 4 = severe affection.

(C) Nasometry:

We assessed nasalance using Nasometer II 6400 (Kay Elemetric Corporation, Lincoln Park, NJ), which was used for the analysis of speech samples of all patients.

We asked all subjects to repeat two sentences in Arabic:

(I) Nasal sentence (/mama betnayem manal/) (This means: Mother helps a girl named Manal to sleep).

(II) Oral sentence (/Ali rah yelab korah/) (This means: A boy named Ali went to play football).

We applied speech assessment one to two days preoperatively, then one month and three months after the operation, and speech evaluators were blind to the technique used.

Surgical Technique

Group (A) patients: underwent FESS by Messerklinger technique.

Group (B) patients: underwent septoplasty with or without turbinate surgery.

Statistics

We collected, tabulated, and analyzed the data using SPSS statistical package Version 15 for windows. We performed a comparison between preoperative and late postoperative speech evaluations. We presented qualitative data as numbers and corresponding percentages. We used the chi square test to compare between variables. We presented quantitative data as mean and standard deviation and compared using paired *t*-test. We considered $p < 0.05$ to be significant and $p < 0.001$ to be highly significant.

Table 1 Preoperative and postoperative results of APA for both groups

	Group (A)			Group (B)		
	pre-op.	1m post-op.	3m post-op.	pre-op.	1m post-op.	3m post-op.
APA	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Hyponasal	3 (13%)	1 (4%)	1 (4%)	9 (36%)	5 (20%)	5 (20%)
Hypernasal	0 (0%)	5 (22%)	1 (4%)	0 (0%)	5 (20%)	1 (4%)
Normal	20 (87%)	17 (74%)	21 (92%)	16 (64%)	15 (60%)	19 (76%)
Chi-square	–	6.24	2.02	–	6.18	2.4
P value	–	0.044*	0.36	–	0.046	0.3

Abbreviations: pre-op., preoperative; post-op., postoperative.

Results

We included forty-eight Egyptian patients in this study. They were 31 men (64.6%) and 17 women (35.4%) and their ages ranged from 18 to 58 years (mean age = 38.5 years).

Group (A) included 23 (16 men and 7 women) patients who underwent FESS by Messerklinger technique; whereas group (B) included 25 patients (15 men and 10 women) who underwent septoplasty with or without turbinoplasty.

Velopharyngeal nasoendoscopy showed competent (normal) closure of velopharyngeal valve in all study participants.

Upon reviewing the APA results from group (A), they revealed the presence of hyponasal speech in 3 out of the 23 patients (13%), while the rest of the group showed normal speech. One month postoperative assessment revealed that only one patient (4%) had hyponasality while 5 (22%) had hypernasality. These results showed a highly significant difference when compared with the preoperative results. Finally, three months postoperative assessment showed that only one patient (4%) had hyponasality and another one (4%) had hypernasality. These results, when compared with the preoperative ones, showed non-significant difference (►Table 1).

With regards to the results of the nasometry for the same group (group A), preoperative nasalance scores were 11 ± 3 for oral sentence and 49 ± 5 for nasal sentence. These scores increased one month postoperatively to 19 ± 4 for oral sentence and 59 ± 4 for nasal sentence and this increase is

statistically highly significant. Then, these scores return to be near the preoperative scores 3 months postoperatively as they were 13 ± 5 for oral sentence and 52 ± 3 for nasal sentence with non-significant increase when compared with the preoperative scores (►Table 2).

Upon reviewing the results of group (B), preoperative APA results revealed 9 out of 25 patients (36%) with hyponasal speech, while the rest of the group showed normal speech. One month postoperative APA assessment revealed that only 5 out of 25 patients (20%) still had hyponasality, while 5 (20%) had developed hypernasality with highly significant difference when compared with the preoperative results. At three months postoperatively, the APA assessment showed that only 5 out of 25 patients (20%) still had hyponasality and only 1 out of 25 (4%) still had hypernasality, with non-significant difference when compared with the preoperative results (►Table 1).

With regards to the results of the nasometry for the same group (group B), preoperative nasalance scores were 8 ± 4 for oral sentence and 44 ± 5 for nasal sentence. At one month postoperatively they were 17 ± 5 for oral sentence and 55 ± 6 for nasal sentence with highly statistically significant difference, when compared with the preoperative scores. Then, three months postoperatively the scores were 9 ± 3 for oral sentence and 46 ± 3 for nasal sentence with non-significant difference when compared with the preoperative scores (►Table 2).

Table 2 Preoperative and postoperative results of nasometry of both groups

	Group (A)			Group (B)		
	pre-op.	1m post-op.	3m post-op.	pre-op.	1m post-op.	3m post-op.
Nasometry	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
Oral sentence	11 ± 3	19 ± 4	13 ± 5	8 ± 4	17 ± 5	9 ± 3
T	–	7.67	1.65	–	7.03	4
P	–	0.001	0.1	–	0.001	0.3
Nasal sentence	49 ± 5	59 ± 4	50 ± 3	44 ± 5	55 ± 6	46 ± 3
T	–	7.49	0.82	–	6.75	1.71
P	–	0.001	0.41	–	0.001	0.09

Abbreviations: pre-op., preoperative; post-op., postoperative; SD, standard deviation.

Thus, nasometry for both oral and nasal sentences also showed significant increase in nasalance scores during the one-month postoperative assessment and then decreased again to near preoperative results at three months postoperative in both groups.

Discussion

Although the importance of certain supraglottic airspace resonators on the primary laryngeal sound is generally acknowledged, there is controversy concerning the real contribution of the nasal cavity and paranasal sinuses on speech.¹²

Nasality is one of the resonance disorders. Subjective judgments of nasality are made based on the perceptions of speech pathologists. However, subjective judgments often are incorrect. Therefore, several attempts have been made to objectively evaluate nasality.²

The development of computerized acoustic analysis systems as an objective measure of voice has become readily available using a simple noninvasive technique.¹³

Many studies have been conducted worldwide to assess nasality in patients with cleft palate, motor speech disorders, hearing impairment, and functional nasality problems, but researchers must pay more attention to the relationship between nasality and functional endoscopic sinus surgery (FESS).⁶⁻⁸

The current study aimed at studying the relation between nasality and various types of endonasal surgeries including, FESS, septoplasty, and turbinoplasty. We also tried to estimate whether the effect of these endonasal surgeries on nasalance scores is permanent or temporary in terms of regaining preoperative values after a considerable period of time.

Results of both APA and nasometry in group (A) denoted that CRS may lead to mild degree of hyponasality (preoperative results). When CRS was managed by FESS, there was a highly significant degree of hypernasality, which appeared in the results of one month postoperative APA and nasometry. However, incidence of hypernasality decreased in the three months postoperative assessment (→ **Tables 1** and **2**). These results agreed with those of Soneghet et al,¹² which found that FESS, despite being a minimally invasive technique, may lead to hypernasal speech.

Hong et al⁶ also reported that the mean value of nasalance in patients with nasal polyposis was significantly lower than that of the healthy controls before FESS, but three weeks after surgery the patients' mean values had improved and were equal to those of the healthy controls.

Results of group (B) (septoplasty and turbinate surgery group) showed some similarity to those of group (A), but the incidence of preoperative hyponasality was higher than in group (B) (→ **Tables 1** and **2**). This may be due to the presence of actual nasal obstruction in this group.

The results of the nasometry in both groups were nearly similar to other researchers who used different types of nasometric languages for evaluation and scoring of nasalance.^{14,15} These results were also similar to several researches,¹⁶⁻¹⁸ which demonstrated significant increases in nasalance scores, suggesting an increase in nasal acoustic energy.

This also, matched the opinions which reported that the anterior nasal obstruction due to septal deviation or hypertrophy of the inferior turbinate increases the resistance to nasal airflow and sound transmission by reducing nasal airway patency. This may create enough impedance to reduce or even prevent sound from entering the nasopharynx, even when the velopharyngeal port is open during speech. On the other hand, obstruction of the anterior nasal cavity may add acoustic aspects to the speech signal that result in "cul-de-sac" resonance.^{17,18}

Although septoplasty does not affect the larynx or changes the structure of the vocal tract it decreases the pitch of the voice and the resonance so, it can consequently decrease the nasal resonance values which improve speech quality.¹⁵⁻¹⁸

The results of both groups are matched with those of Behrman et al,¹⁹ who stated that the decreased tissue surface area and widened nasal passages after surgery will decrease the acoustic damping and increase the acoustic coupling with the paranasal sinuses, thereby increasing the amplitude or energy of the voice.

The increase of the nasalance in the first month after the operation is due the fact that the nasal cavity is usually covered with a mucosal crusting, resulting in decreased vibration. Decreased energy dampening, in turn, leads to more energy transfer to the nasal cavity.²⁰

Normalization of nasality within an average of six weeks postoperatively may be due to the decrease of crusts and healing of the nasal and sinus cavity mucosa; subsequently, mucosal vibration and dampening function may normalize. In addition, if the middle turbinates properly cover the ethmoid and maxillary ostium, resonance might occur separately in the sinus and nasal cavities. As the patients have normal velopharyngeal function, the airflow regulation according to the changed nasal/oral impedance may also contribute to normalization of nasality.²¹

Endonasal operations cause widening of the nasal resonating cavities. This widening effect is not obvious during the early days and weeks after surgery due to the effect of edema and congestion which subside gradually. The widening of the nasal resonating cavities reaches its maximum after one month, which enhances nasal resonance and leads to increased nasalance. With time, the size of these cavities may decrease slightly again, leading to decreased nasalance again.

To the best of our knowledge, this was the first study dealing with the effect of endonasal surgeries on nasalance to be conducted on Arabic speakers. We also used the nasometric Arabic nasal and oral sentences.

Future studies are still needed for further evaluation of postoperative changes in nasalance scores in patients with severe disease and extensive nasal polyposis.

Conclusion

FESS, septoplasty, and turbinate surgery may lead to hypernasal speech, which may be due to changes in the shape and diameter of the resonating vocal tract.

Hypernasal speech in these circumstances may be a temporary finding that can decrease with time.

Surgeons should inform their patients about the possibility of temporary hypernasality after these types of surgery, especially if they are professional voice users.

References

- 1 Sataloff RT. Clinical anatomy and physiology of the voice. In: *Professional Voice: The Science and Art of Clinical Care*. New York, NY: Raven Press; 1991:7–18
- 2 Jiang RS, Huang HT. Changes in nasal resonance after functional endoscopic sinus surgery. *Am J Rhinol* 2006;20(04):432–437
- 3 Fletcher SG, Adams LE, McCutcheon MJ. Nasalance shaping routines. In: *Instruction Manual for the Nasometer Model 6200*. Pine Brook, NJ: Kay Elemetrics Corp; 1988
- 4 Dalston RM, Warren DW, Dalston ET. Use of nasometry as a diagnostic tool for identifying patients with velopharyngeal impairment. *Cleft Palate Craniofac J* 1991;28(02):184–188, discussion 188–189
- 5 Dalston RM, Warren DW, Dalston ET. A preliminary investigation concerning the use of nasometry in identifying patients with hyponasality and/or nasal airway impairment. *J Speech Hear Res* 1991a;34(01):11–18
- 6 Hong KH, Kwon SH, Jung SS. The assessment of nasality with a nasometer and sound spectrography in patients with nasal polyposis. *Otolaryngol Head Neck Surg* 1997;117(04):343–348
- 7 Hosemann W, Göde U, Dunker JE, Eysholdt U. Influence of endoscopic sinus surgery on voice quality. *Eur Arch Otorhinolaryngol* 1998;255(10):499–503
- 8 Chen MY, Metson R. Effects of sinus surgery on speech. *Arch Otolaryngol Head Neck Surg* 1997;123(08):845–852
- 9 Kotby N, Abdel Haleem EK, Hegazi M, Safe I, Zaki M. Aspects of assessment and management of velopharyngeal dysfunction in developing countries. *Folia Phoniatri Logop* 1997;49(03/04):139–146
- 10 Emara TA, Quriba AS. Posterior pharyngeal flap for velopharyngeal insufficiency patients: a new technique for flap inset. *Laryngoscope* 2012;122(02):260–265
- 11 Golding-Kushner KJ, Argamaso RV, Cotton RT, et al. Standardization for the reporting of nasopharyngoscopy and multiview videofluoroscopy: a report from an International Working Group. *Cleft Palate J* 1990;27(04):337–347, discussion 347–348
- 12 Soneghet R, Santos RP, Behlau M, Habermann W, Friedrich G, Stammberger H. Nasalance changes after functional endoscopic sinus surgery. *J Voice* 2002;16(03):392–397
- 13 Dang J, Honda K, Suzuki H. Morphological and acoustical analysis of the nasal and the paranasal cavities. *J Acoust Soc Am* 1994;96(04):2088–2100
- 14 Kim YH, Lee SH, Park CW, Cho JH. Nasalance change after sinonasal surgery: analysis of voice after septoturboplasty and endoscopic sinus surgery. *Am J Rhinol Allergy* 2013;27(01):67–70
- 15 Mora R, Jankowska B, Dellepiane M, Mora F, Crippa B, Salami A. Acoustic features of voice after septoplasty. *Med Sci Monit* 2009;15(06):CR269–CR273
- 16 Van Lierde KM, Wuyts FL, De Bodt M, Van Cauwenberge P. Age-related patterns of nasal resonance in normal Flemish children and young adults. *Scand J Plast Reconstr Surg Hand Surg* 2003;37(06):344–350
- 17 Pegoraro-Krook MI, Dutka-Souza JCR, Williams WN, Teles Magalhães LC, Rossetto PC, Riski JE. Effect of nasal decongestion on nasalance measures. *Cleft Palate Craniofac J* 2006;43(03):289–294
- 18 Watterson T, Lewis KE, Deutsch C. Nasalance and nasality in low pressure and high pressure speech. *Cleft Palate Craniofac J* 1998;35(04):293–298
- 19 Behrman A, Shikowitz MJ, Dailey S. The effect of upper airway surgery on voice. *Otolaryngol Head Neck Surg* 2002;127(01):36–42
- 20 Borden GJ, Harris KS, Raphael LJ. Acoustics. In: *Physiology, Acoustics, and Perception of Speech* Raphael LJ (Eds). Philadelphia: Lippincott Williams & Wilkins; 2007:31–53
- 21 Jones DL. Patterns of oral-nasal balance in normal speakers with and without cleft palate. *Folia Phoniatri Logop* 2006;58(06):383–391